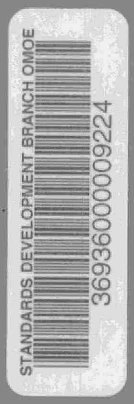

GASOLINE CONTAMINATION OF A PRIVATE WELL SUPPLY

township of whitchurch-stouffville-
community of ballantrae

r. e. mcarthur

1973

Ontario
Ministry
of the
Environment

MINISTRY OF THE ENVIRONMENT

TOWNSHIP OF WHITCHURCH - STOUFFVILLE - COMMUNITY OF BALLANTRAE

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R. E. McArthur

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MINISTRY OF THE ENVIRONMENT

TOWNSHIP OF WHITCHURCH - STOUFFVILLE - COMMUNITY OF BALLANTRAE GASOLINE CONTAMINATION OF A PRIVATE WELL SUPPLY

INTRODUCTION

In response to a request from Mrs. Jack Radford, the Water Quantity Management Branch conducted an investigation to determine the cause and extent of petroleum contamination of the ground water supplying wells in the Community of Ballantrae.

The study included field examination of water wells and excavations, the collection of ground water and sediment samples for chemical analysis, a levelling survey, and interviews with local residents.

The branch also provided Shell Canada representatives with information concerning steps to be taken to remove the gasoline contaminant from the aquifer and prevent further well contamination in the community.

BACKGROUND

On October 16, 1972, Mrs. Jack Radford telephoned Mr. R. McArthur of this branch to report that a water sample taken from the Radford well by Mr. Paynes of the Regional Municipality of York Health Unit contained 5 ppm (parts per million) of petroleum product. Mrs. Radford indicated that water from the well, which serves the Radford Shell Service and Snack Bar as well as the Radford residence, had developed gasoline odours as early as the second week in September, 1972.

Mr. Radford reported that old tankage at

Radford's Shell Service had been abandoned but not removed from the ground. One of these abandoned tanks, a 500-gallon gasoline tank, had reportedly been used as recently as 1970.

Since the buried storage facilities at Radford's Shell Service represented the closest possible source for the hydrocarbons found in the well, the Ministry of Consumer and Commercial Relations was requested to determine the soundness of these facilities.

On October 20, 1972, Mr. A. MacIver of the Fuel Safety Section of the Ministry of Consumer and Commercial Relations, Mr. W. Grattan of Shell Canada Limited and Mr. R. McArthur of this branch met at Radford's Shell Service to determine the source of the petroleum hydrocarbon in the Radford well.

Mr. MacIver located a leak in a poorly tightened union at the junction of the gasoline suction line and the dispenser plumbing. The point of leakage was about 60 feet from the contaminated well. It was learned that this dispenser was a recent replacement and that the faulty union had been installed on September 8, 1972, only about one week before the occurrence of gasoline odours in the Radford well.

The original position of the gasoline dispenser at Radford's Shell Service, local residences and their water supply wells, and various excavations are represented in Figure 1.

On October 23, 1972, the abandoned gasoline storage facilities which consisted of two 500-gallon tanks and one 1000-gallon tank were removed from excavation No. 1.

The tanks were closely examined visually and proved to be quite sound. There was no apparent corrosion and the sediments from excavation No. 1 were dry and odourless despite the fact that one of the 500-gallon tanks yet contained 146 gallons of gasoline.

Excavations east of the gasoline dispenser island revealed that the soil in this area was contaminated with gasoline. This area was excavated to remove as much of the contaminated sediments as possible. The contaminated sediments were disposed at the York Sanitation landfill site in the Township of Whitchurch-Stouffville as authorized by the Waste Management Branch.

As the excavation east of the dispenser was advanced, it was found that gasoline odours were present in the sediments below and west of the dispenser. The excavation was extended as far westward as possible without disturbing the road bed of Highway 48. The pit was extended vertically to the water table where the greatest concentration of gasoline was located.

A separate gasoline phase ponding on the water table surface, 22 feet below the leaking union, was apparent by its odour and red colouring on November 2, 1972. Pumping was carried out in this area and Mr. Grattan reported that approximately 40 gallons of gasoline was recovered.

The excavation could not proceed onto highway property, however, it was expected that lost product would gradually leach into the ground water from this area. Therefore, it was recommended that a collector well be installed near the gasoline dispenser in order that the

gasoline phase could be pumped off the water surface as it collected there. It was felt that periodic pumping of the collector well would affectively control this problem.

On November 27, 1972, a sampling program was undertaken employing the collector well. The well was pumped continuously at 5 gallons per minute for 3 hours and 7 samples were taken from the pumping stream. An analysis of the chemical data suggested that the bulk of the gasoline could be removed from this area with only 3 hours of pumping. Thus, Shell Canada Ltd. was advised that such 3-hour pumping programs should be carried out periodically to remove the residual product before it could migrate to the Radford well.

A water sample taken from the Radford well on March 9, 1973, demonstrated no gasoline odour. Mrs. Radford indicated that the gasoline odours had not been apparent in the water for some time and that the water could now be used for drinking.

On May 8, 1973, the collector well was again pumped for the required 3-hour period. Although the first sample taken from the pumping stream contained 40 ppm of gasoline the last sample contained only 3.5 ppm. A sample taken from the Radford well on this occasion demonstrated no evidence of gasoline contamination.

HYDROGEOLOGY

The surface topography in the Ballantrae area is subdued, with only a slight slope toward the south-east apparent in the spill area.

The surface materials are mapped as kame moraine[1] and excavations at the site demonstrated the persistence of these coarse-grained, ice-contact materials to the water table approximately 22 feet (6.7m) below the surface.

Ground-water supplies in the area are obtained from dug wells which intersect the water table at 15 to 21 feet (4.6 to 6.4m) below the surface.

A levelling survey undertaken on October 23, 1973, demonstrated the local water table to be relatively flat with the elevation of water in the Radford well slightly lower than surrounding wells. This suggests that the Radford domicile, garage and restaurant operation used a greater volume of water than other wells in the area on the day of the survey. This probably represents a general condition since Radford's is the only commercial operation in the area with the exception of Ballantrae Motors which is reported to use only a small amount of water. Thus, ground water flows radially toward the Radford well when the well is in use.

CHEMICAL QUALITY

An examination of the water quality analyses listed in Table 1 reveals that the Radford well water contained chloride, oxidized nitrogen compounds, and phenols at concentrations in excess of the Ministry's permissible criteria for public water supplies of 250 ppm, 10 ppm and virtually absent, respectively, during the time of the initial investigation. In addition, the concentration of

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1 *Chapman L.J., and Putnan D.F. - The Physiography of Southern Ontario, Second Edition - University of Toronto Press-1966.*

sodium and hardness in this water supply is excessively high, with a hardness of 200 ppm greater than other wells in the area.

Of the wells examined, only the Radford well has produced water containing gasoline residues and odours. To demonstrate the presence of gasoline in the Radford well water by conventional gas chromatography analysis, a charcoal filtration program was initiated. This was required because human sensitivity to gasoline in water is approximately 10 times more acute than the chromatography currently available. The program involved filtration of the hydrocarbon from the well water on a charcoal charge over a 5-day period of continuous flow at 1 gallon per minute. The hydrocarbon was leached from the charcoal with an organic solvent and the chromatography revealed 3 of the 4 components associated with gasoline.

An analysis of a ground-water sample taken from the excavation below the leaking union on November 2, 1972, contained 540 ppm of gasoline, and a distinct gasoline phase was evident. In addition, phenols which are commonly associated with petroleum hydrocarbons were found at a concentration of 440 ppb (parts per billion) in this sample.

The chemical analyses of samples taken during the November 27, 1972 and May 8, 1973 pumping of the collector well are presented in Table 2. During the initial pumping of this well the concentration of gasoline in the effluent from the collector well increased with continued pumping at 5 gpm from an initial value of 75 ppm to a maximum of 854 ppm, 30 minutes after pumping began. The gasoline

concentration then decreased continuously to 19 ppm at the end of 3 hours of pumping. The second pumping of this well reduced the concentration of gasoline from 40 ppm to 3.5 ppm.

Table 3 is a summary of the analyses of sediment samples taken from excavations on the Radford property. Samples taken from shallow test holes 1 and 2 respectively, revealed the presence of gasoline-like hydrocarbon mixtures at both locations. Samples C, F and G demonstrate the presence of gasoline-like mixtures at various depths in Excavation 2.

DISCUSSION

The evidence suggests that ground water flows from a significant area toward the Radford well when it is in use. Since the soil materials above the water table are relatively coarse, any contaminant introduced to the soil in the immediate vicinity will move toward the Radford well.

The chloride concentration in the Radford well water is greater than the Ministry's permissible criterion of 250 ppm and considerably higher than that of neighbouring wells tapping the same aquifer. Since the Radford domestic septic tank is only about 7 meters from the well it is expected that a small amount of the chlorides may enter the well from septage leaching through the soil. However, it is felt that de-icing salt from Highway 48 is the principal source of chlorides in the Radford well. Although the road surface is about 22 meters from the well, the asphalt pad adjacent to the gasoline vendor promotes some drainage from an area very near the garage toward the

well. Thus, some salt left in the area of the Radford garage by vehicles coming from Highway 48, will gain access to the soil only 6 meters from the well. In addition, commercial vehicles which park in the area between the garage and store buildings are commonly less than 1 meter from the well.

The chloride concentration in a sample taken from the Radford well on March 9, 1973, was 746 ppm as compared to concentrations of approximately 350 ppm found in samples taken from the well in the fall of 1972. Although an increase would be anticipated due to the winter application of de-icing salt, it is felt that the situation may have been intensified by the absence of the asphalt pad which was removed to permit the excavation of gasoline contaminated sediments. Thus, it is expected that replacement of the asphalt pad at Radford's Shell Service will ameliorate the chloride problem to some degree.

In addition to elevated chloride concentrations, the contamination of ground waters by de-icing salt, which is essentially sodium chloride, also results in increased sodium levels. Since sodium ions may exchange with calcium and other hardness ions as it moves through the soil lattice, an increase in the hardness of the ground water is also to be expected. Thus, de-icing salt may be contributory to the excessive hardness as well as the large sodium and chloride concentrations in the Radford well water.

The Radford's have combatted the excessive hardness of their well water with the installation of a water softening unit. However, the softening process introduces

sodium into the treated water and since the entire domestic supply is treated at the Radford residence, this has resulted in a substantial increase in the sodium content of the drinking water. This is evidenced by comparative water samples taken from the well and distribution system on October 20, 1972. On this occasion, the well water contained 355 ppm of sodium whereas the treated water as taken from the kitchen cold water tap contained 700 ppm of sodium. According to McKee[2], "Sodium in drinking water may be harmful to persons suffering cardiac, renal, and circulatory diseases, and as much as 200 mg of sodium from drinking water may be injurous." Furthermore, objectionable mineral tastes in the Radford well water (which is used in coffee for the Radford Snack Bar) have been reported. Lockhart et al[3] has determined that the taste threshold of sodium, as sodium chloride, in distilled water is 135 ppm.

The total oxidized nitrogen (nitrite and nitrate) in the Radford well water exceeded the permissible criteria of 10 ppm in samples taken on October 20, 1972, and on March 9, 1973. High nitrate values are an indication that septic tank leachate is reaching the well. This is corroborated by the presence of organic nitrogen, and soluble phosphorous which also derive from septic systems as well as the occasional bacterial infestations which have been determined by the Regional Municipality of York Health

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2 *McKee, J.E. and Wolf, H.W. - Water Quality Criteria 2nd Edition, The Resources Agency of California, State Water Quality Board, Sacremento, California, Publication No. 3-A (1963)*

3 *Lockhart, E.E., Tucker, C.L., and Merritt, M.C., "The Effect of Water Impurities on the flavour of Brewed Coffee" Food Research 20, 598 (1955)*

Unit. The presence of nitrogen and phosphorous nutrients has resulted in a biochemical oxygen demand which is significantly higher than that of other wells in the area.

Phenols, or the hydroxy derivatives of benzene and its condensed nuclei, are associated with and commonly found in petroleum hydrocarbons. In this case, a sample taken from the water table surface in the excavation at the leaking union contained a layer of pure gasoline and 440 ppb of phenols. Only the more soluble components of gasoline were found in the test hole sediments and the Radford well water, whereas the more soluble phenols were found in concentrations as high as 200 ppb in the Radford well. Subsequent to the excavation of contaminated sediments and pumping of the excavation and collector well, there is no evidence of gasoline in the Radford well and the phenols have been reduced to background levels of less than 10 ppb.

CONCLUSIONS

A faulty union in the plumbing connecting the gasoline dispenser and storage facility at Radford's Shell Service, resulted in the contamination of sediments and ground water with gasoline and phenols. Some of the contaminant reached the Radford well and rendered the water unfit for human consumption for some time.

Excavation and removal of contaminated sediments and ground water plus a program of periodic pumping of a collector well established in the affected area has thus far been effective in eliminating the hydrocarbon contaminant from the Radford well water. Continuation of this periodic pumping program may prevent the spread of hydrocarbon contaminants to other wells in the community, as well as the

recurrence of hydrocarbon contaminants in the Radford well. The abandoned underground storage facilities are not responsible for the ground-water contamination affecting the Radford well.

In addition to the gasoline contaminant, the Radford well displays contamination by road salt and septic wastes.

ALTERNATE SUPPLIES

It is felt that replacement of the asphalt pad with appropriate levees preventing surface drainage toward the well may reduce the concentration of chlorides and sodium in the ground water supplying the well. The chloride and sodium concentrations may be further reduced by paving and appropriately draining the area between the garage and the store which is used by supply vehicles. A significant reduction of the sodium imput to the local ground water will be accompanied by a similar reduction in the hardness of the well water. The sodium concentration in the Radford drinking water can be significantly reduced immediately by connecting the water softener to only the hot water system.

Reduction of the nitrate concentrations and elimination of the occasional bacterial infestations in the water supply may be obtained by increasing the separation between the well and the septic system. This separation may be achieved through one of the following alternatives:

1) A new well may be constructed beyond the contaminated zone at least 100 feet in an easterly direction from the septic tile beds. If this alternative is selected, any connecting lines should be of metal

construction as plastics are permeable to petroleum hydrocarbons.

2) The domestic septic field is reported to be a considerable distance from the septic tank. Thus, the elimination of any leakage between the tank and field may significantly improve the quality of water obtained from the existing domestic supply well.

3) The septic system which services the Radford garage is appropriately remote from the well, and may be capable of handling the added load of the domestic wastes. It may be possible to conduct the domestic septage directly to the septic system at the garage to facilitate the requisite improvement in water quality at the domestic well. The York Regional Health Unit should be consulted to determine if the garage's septic system design is adequate for the additional load.

RECOMMENDATION

1. Shell Canada Limited should periodically pump the collector well near the pump island, as outlined in this report, to prevent the spread of hydrocarbon contaminants in the aquifer.

2. Since the aquifer in the vicinity is particularly vulnerable to contamination, de-icing salt should be applied prudently to the road surfaces in the area.

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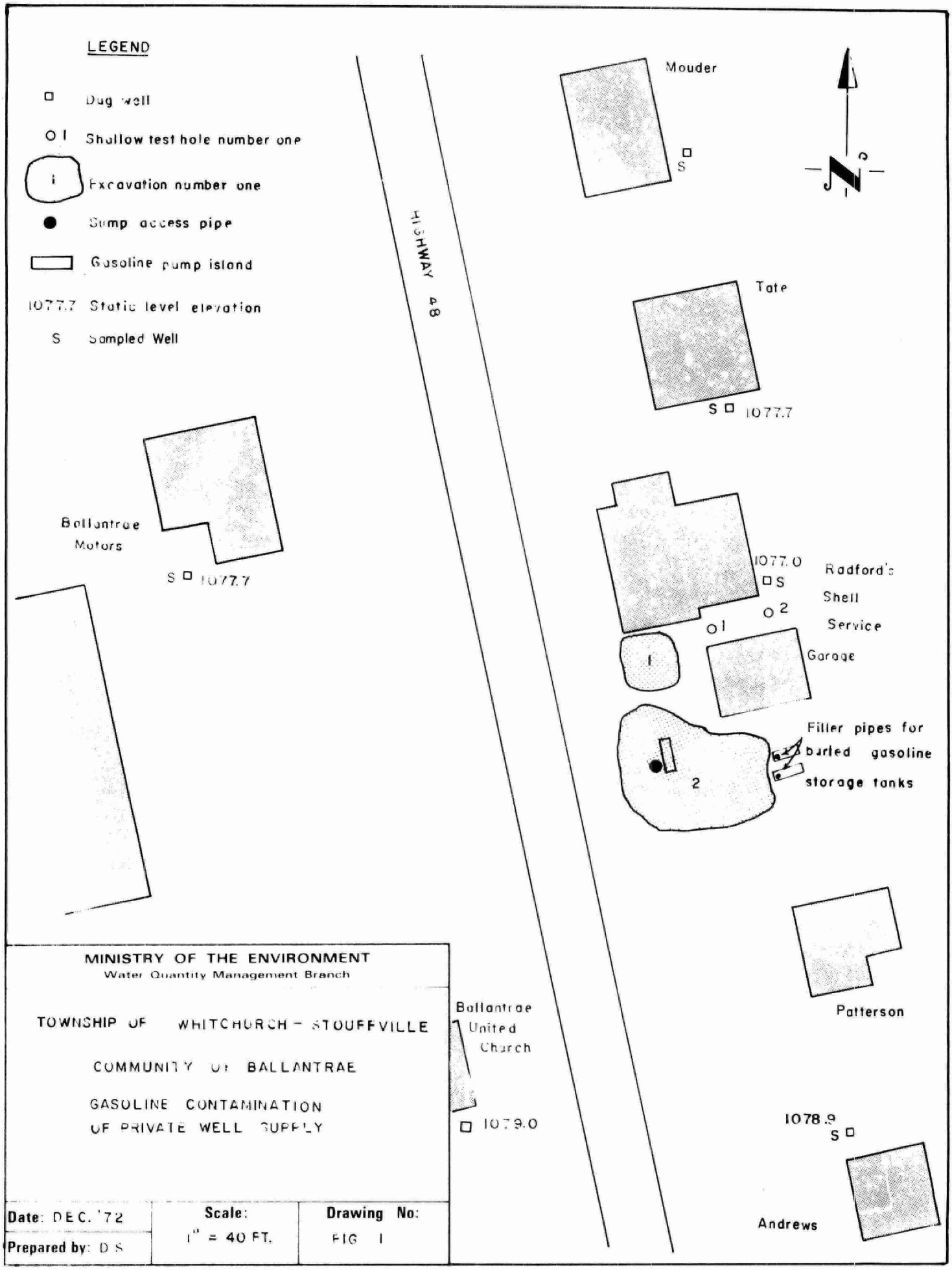
LEGEND
Dug well
Shallow test hole number one
Excavation number one
Sump access pipe
Gasoline pump island
1077.7 Static level elevation
S Sampled Well
HIGHWAY 48
Mouder
S
Tate
S 1077.7
Ballantrae Motors
S 1077.7
1077.0
S
Radford's Shell Service
O 1
O 2
1
Garage
2
Filler pipes for buried gasoline storage tanks
Patterson
Ballantrae United Church
1079.0
1078.9
S
Andrews
MINISTRY OF THE ENVIRONMENT
Water Quantity Management Branch
TOWNSHIP OF WHITCHURCH - STOUFFVILLE
COMMUNITY OF BALLANTRAE
GASOLINE CONTAMINATION
OF PRIVATE WELL SUPPLY
Date: DEC. '72
Prepared by: D S
Scale: 1" = 40 FT.
Drawing No: FIG 1

MINISTRY OF THE ENVIRONMENT

Table 1 Summary of Water Analyses

Prepared by D. SMITH

Source and Number	Location	Date Sampled	pH	Phosphorus as P		Gas	Phenol	Total Hardness as $CaCO_3$ (ppm)	Alkalinity as $CaCO_3$ (ppm)	Chemical Constituents in parts per million (ppm)										B.O.D	Remarks
				Total	Solution					Chloride (Cl)	Sulphate (SO_4)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potasium (K)	Nitrogen as N: Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	
R MOUDER DRILLED WELL	KITCHEN TAP	OCT 25/72	7.6			N.D.	0	302	184	24		1.90									1.6	
E. TATE DUG WELL	KITCHEN TAP	OCT 25/72	7.6			N.D.	0	282	278	179		0.30									0.4	
ANDREWS DUGWELL	HANDPUMP	OCT. 25/72	7.5			N.D.	0	380	212	116		0.50									0.8	
BALLANTRAE MOTORS DUG WELL	GARAGE TAP	OCT. 25/72	7.2			N.D.	7	472	352	96		0.20									2.0	
J. RADFORD DUG WELL	SURFACE OF WATER	OCT 25/72	7.1			N D	120	684	474	320		7.2									9.5	IRIDESENCE
J. RADFORD DUG WELL	KITCHEN TAP	OCT. 20/72	7.4		0.13	GAS RESIDUE	80	38	502	368		1.3	14	<1	700	7.5	0.05		49	10	11.0	AFTER SOFTENER
J. RADFORD DUG WELL	SURFACE OF WATER	OCT. 20/72	7.3	0.60	.062	GAS RESIDUE	200	672	547	342		2.0	243	16	355	20	<.01	1.3	.038	16	8.5	IRIDESCENT SCUM
J. RADFORD WELL	CHARCOAL FILTER	OCT. 23 TO OCT. 27				SOME AROMATIC HYDROCARBONS *																5 DAY FILTER RESIDUE FROM BATH TAP
J. RADFORD	KITCHEN TAP	MAR. 9/73	7.3	1.4	1.1	N.D.		96	335	746		0.05	34	2	632	12	0.01	0.66	.022	19.0		
	KITCHEN TAP	MAY 8/73					4															NO GAS ODOUR
J. RADFORD	OPEN PIT	NOV 2/72				540 **	440															

MINISTRY OF THE ENVIRONMENT

Table 1 Summary of Water Analyses
CONT.

Prepared by D. SMITH

Source and Number	Location	Date Sampled	pH	Phosphorus as P		Gas (ppm)	Phenol (ppb)	Total Hardness as $CaCO_3$ (ppm)	Alkalinity as $CaCO_3$ (ppm)	Chemical Constituents in parts per million (ppm)											B.O.D	Remarks
				Total	Solution					Chloride (Cl)	Sulphate (SO_4)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potasium (K)	Nitrogen as N					
																	Free Ammonia	Total Kjeldahl	Nitrite	Nitrate		

NOTES: * THE CHARCOAL CHARGE WHEN EXTRACTED WAS FOUND TO CONTAIN THREE (3) OF THE FOUR (4) COMPONENTS ASSOCIATED WITH GASOLINE

** THE SAMPLE CONTAINED 540 ppm GASOLINE. THIS FIGURE IS MUCH HIGHER THAN IS POSSIBLE FOR THE SOLUBILITY OF GASOLINE IN WATER - HOWEVER, THE SAMPLE AND ITS CONTAINER WERE EXTRACTED AND THIS FIGURE COULD INCLUDE GASOLINE FORMING A SURFACE FILM OR GASOLINE ADHERING TO THE CONTAINER WALLS.

MINISTRY OF THE ENVIRONMENT

Table 2 Summary of Water Analyses

Prepared by D. SMITH

Source and Number	Location	Date Sampled	Hydrocarbons ppm GASOLINE	Phenols ppb	Odour / Taste
J. RADFORD	GASOLINE ISLAND SUMP	NOV. 27/72 1010 HR	75		
PUMP TEST AT 5 gpm		1017 HR	98 *		
		1025 HR	408 *		
		1040 HR	854 *		
		1110 HR	114 *		
		1210 HR	59		
		1310 HR	19		

* SAMPLE HAD GASOLINE FLOATING ON SURFACE AND ADHERING TO THE CONTAINER WALLS. THE SAMPLE AND ITS CONTAINER WERE EXTRACTED. THUS THE RESULTS REPRESENT THE TOTAL AMOUNT OF GASOLINE IN THE CONTAINER AND ARE CALCULATED ON THE TOTAL SAMPLE VOLUME

Source and Number	Location	Date Sampled	Hydrocarbons ppm GASOLINE	Phenols ppb	Odour / Taste
J. RADFORD PUMP TEST AT 5 gpm	WELL SURFACE BEFORE START	MAY 8/73 1000	40		
		1005	8.6		
	PUMP FAILURE				
	START	1410 HR	4.8		
		1415 HR	6.4		
		1425 HR	3.5		
		1440 HR	4.2		
		1510 HR	4.2		
		1610 HR	3.5		
		1710 HR	—	4	

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MINISTRY OF THE ENVIRONMENT

Table 3 Summary of Water Analyses

Prepared by D.SMITH

Source and Number	Date Sampled	Location	Hydrocarbons
TEST HOLE 1	OCT. 24/72	ELECTRIC SERVICE LINE FROM HOUSE TO GARAGE BUILDING, 6FT FROM HOUSE	MORE THAN A TRACE OF GASOLINE-LIKE MIXTURE
TEST HOLE 2	OCT. 27/72	FINE SAND 10 FT. SOUTHEAST OF RADFORD WELL D = 3.5 ABOVE CALICHE, NO GAS SMELL	N.D.
EXCAVATION 2 STATION A	OCT. 24/72	EAST OF AND UNDER PUMP ISLAND FROM 4-6 IN BELOW TARMACK	LARGER AMOUNT OF GASOLINE-LIKE MIXTURE THAN TEST HOLE 1
" STATION B	OCT 25/72	SEDIMENT SAMPLE (FINE GRAVEL) 8FT BELOW LEAKING DISPENSER	PRESENCE OF GASOLINE-LIKE MIXTURE
" STATION C	OCT. 27/72	FINE SAND, SOUTH WALL DISPENSER PIT, D = 3.0 WET UPPER SEDIMENTS, NO GAS SMELL	N.D.
" STATION D	OCT. 27/72	FINE SAND, SOUTH WALL DISPENSER PIT D = 4.5 1.0FT BELOW WET SEDIMENT, NO GAS SMELL	N.D.
" STATION E	OCT. 27/72	MEDIUM-COARSE SAND, SOUTH WALL DISPENSER PIT D = 10.0FT, FINE LENS IN LOWER GRAVEL NO GAS SMELL	LARGER AMOUNT OF GASOLINE-LIKE MIXTURE THAN F
" STATION F	OCT. 27/72	MEDIUM-COARSE SAND, NORTH WALL DISPENSER PIT D=10.0 FT. LOWER GRAVELSEDIMENT STRONG GAS SMELL	TRACE AMOUNT AGED GASOLINE-LIKE MIXTURE
" STATION G	OCT. 27/72	FINE-MEDIUM SAND, 3FT WEST OF SUPER TANK D = 3.5 NO GAS SMELL	N.D.

D = DEPTH OF SAMPLE
N.D. = NON DETECTED

TREATMENT: EACH SEDIMENT WAS TREATED AS FOLLOWS: 10 gm. OF SAMPLE WERE MIXED WITH MAGNESIUM SULPHATE AND ELUTED IN A CHROMATOGRAPHIC COLUMN WITH 20 mL OF CARBON TETRACHLORIDE. THE ELUATE WAS EXAMINED BY GAS CHROMATOGRAPH. THIS STANDARD TREATMENT FOR EACH SEDIMENT MADE IT POSSIBLE TO DETERMINE THE RELATIVE AMOUNTS OF GASOLINE IN THE SAMPLES.